REPORT

ON DYKELAND RECLAMATION
1913 To 1952

by W.W. BAIRD B.S.A.
EXPERIMENTAL FARM NAPPAN N.S.

Experimental Farms Service
CANADA DEPARTMENT OF AGRICULTURE

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W. W. Baird

RECLAMATION OF DYKELANDS IN THE MARITIMES

by

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Brief History

In the early part of the seventeenth century the dykelands of the Maritime Provinces were still in the process of formation. At that time they were large unimproved tracts of low, level land flanking the shores of the rivers and basins of the Bay of Fundy.

These lands are slowly built up by rich silt deposits left after each receding tide. Twice in every 24 hours, during the run of high tides, these lands are covered with the muddy waters from the Bay of Fundy. At the turn of the tide the water is stationary for a short period and it is during this time that thin deposits of very fine, rich soil are made. Thus the process of building continues year after year.

The Acadian colonist settling in Nova Scotia in 1604 and onward first recognized the value of these rich deposits. It was he who first reclaimed them from the sea by the building of mud dykes. It was he who developed the dyking spade and the art of using it. It was he who first taught the art of proper draining of these dykelands. Only a very few descendants of these early settlers remain to exhibit that rare art of spading marsh mud efficiently and effectively. It was then, during the seventeenth century, that the Acadians reclaimed from the sea many hundreds of acres.

When the English took possession of the province in 1749 they were not slow to recognize the potential value of these fertile soils. With the help of the Acadians, they reclaimed many more thousands of acres.

It is estimated that there are today from 70,000 to 80,000 acres dyked in from the sea. Another 15,000 to 20,000 acres probably could be reclaimed by the construction of mud dykes. Some 10,000 to 15,000 acres of this land is somewhat different in soil texture from the average run of dykeland soils, but experimental tests indicate that it can be made very productive when properly drained and cultivated. This latter type of dykeland is for the most part found in Yarmouth County, Nova Scotia. These soils are now growing a V-joint water grass very low in food value but it is cut and fed to livestock.

The most extensive dykeland areas are found at the head of the Bay of Fundy in Westmorland County in New Brunswick and Cumberland County, Nova Scotia, and are known to the world as the famous Tantramar Marshes. There are several other fairly large areas in Hants, Kings, Annapolis, Colchester and Pictou Counties, Nova Scotia, and Albert County, New Brunswick. These lands have all been operated under a Marsh Act in their respective provinces.

Organization

The large areas are subdivided into smaller "bodies" and are generally known by letters, numbers or names. Each Body is supervised by the proprietors, with an appointed Commissioner and Clerk, whose duties are to transact the business for that Body. The Commissioner and Clerk must arrange to have all dykes, aboiteaux and main vent ditches kept in repair and operation.

In Nova Scotia the general practice is that after an expenditure has been incurred within the Body, the clerk assesses each proprietor on the value of his or her property, such values having been set by a board of appraisers. This appraisal remains until such time as a majority of the proprietors ask for re-appraisal. In New Brunswick the assessment has for the most part been worked out on an acre ownership basis.

Early utilization

The early Acadians practised beef raising on these dykelands and the adjacent upland. According to history, they raised beef to feed the French army previous to 1699 and during the eighteenth century raised beef for the Newfoundland trade. Following this a beef trade was developed with Britain. The annual shipment out of the Amherst and Sackville districts was 4,000 to 5,000 head. Unfortunately this British trade was brought to a close in 1892 by an embargo, but a good home market had developed by 1900, through the rapid growth of small towns and villages, lumbering and mining operations. Some surplus livestock was also shipped to the United States.

Soon a good demand for hay developed and money was more easily made by growing hay. Hence hay production gradually replaced the major part of the beef industry and for many years the proprietors of dykeland enjoyed a profitable hay market.

Three factors militated against a further development of the beef industry on and around the dykelands:

(1) The young men found remunerative year-round work in the mines and the woods.
(2) The beef industry was being developed on the prairies and keen competition was soon felt from western beef.
(3) Good returns, were obtained through selling hay, the price of which gradually improved until it struck the peak in 1918, when good hay ranged from $25 to $28 per ton.

This was not to be enjoyed for long, for in 1923 the price of hay fell to $13. per ton and for the next ten years it fluctuated between $13. and $15. per ton. In 1933 it received a major setback: the price dropped to $10. per ton and in 1938 fell to $6. or $7. per ton F.O.B. car. This was the end for the hay farmer, for

after deducting $2.50 per ton for cutting, $1.50 for pressing and 50 cents per ton for cartage, it left nothing for interest or maintenance charges.

When the beef and hay business was good, dykeland was in great demand and the price range was from $125 to $200 per acre but the situation altered rapidly. The low returns from hay for a period of some 17 years resulted in neglect of dykes, aboiteaux and drainage systems, making many of the large areas an easy prey to high winds and storms. Aboiteaux gave way and dykes were swept out to sea. Drainage ditches were filled with mud and while many proprietors endeavoured to maintain their dykelands, their efforts proved fruitless due to neglect of adjacent areas. From 1933 on dykeland values fell rapidly and today many of those tracts of dykeland that found a ready sale at $200 per acre can be bought for $25 to $50 per acre and, in some cases, less.

Rehabilitation

It became apparent that if these once valuable lands were to be restored to their former productive state, some form of assistance was necessary. In 1939 the Maritime Beef Cattle Committee appointed a sub-committee to make a study of the problems confronting the dykeland owners of the Chignecto Isthmus area at the head of the Bay of Fundy. Their findings are of vital interest to dykeland owners:-

1. These dykelands are of economic importance to the agricultural industry of the Maritimes.
2. They have not depreciated beyond economic repair.
3. Some assistance is not only justified but necessary in the rehabilitation of these lands.
4. Dyke and drainage repairs are of major importance.
5. If properly dyked and drained, larger acreages can be sown to grain, thereby supplying the much needed livestock feeds that are now purchased from Western Canada.
6. If properly dyked and drained, large areas can be converted into excellent grazing lands, particularly those adjacent to upland areas.
7. By adopting improved cultural methods production can be more than doubled on large areas.
8. The more suitable broadleaf areas should be plowed and seeded to timothy and clover.
9. With increased grain production, more and better hay and improved grazing land, the breeding and finishing of more and better beef has definite possibilities.
10. Government assistance should be made available to dykeland owners through co-operating with them in determining the most suitable types and makes of machines for dyking, ditching and cultivation.
11. All main vents, creeks and canals should be dredged to facilitate proper drainage.
12. Further study should be given to the economic rehabilitation of dykes and protective measures for same.

13. Further experimental work should be carried out to determine improved economic cultural practices on dykelands.

14. Whole areas should be organized into communities for the purpose of livestock improvement, under supervision, and purebred sires of an approved beef type provided in such centres.

15. Feeding conditions prevailing throughout these areas suggest maximum utilization of pasturage with a minimum of grain.

The report and its findings were submitted to the Experimental Farms Service, Canada Department of Agriculture.

These recommendations were strongly supported by an economic survey report made on some 13,000 acres and submitted by the Nova Scotia Department of Agriculture to the Canada Department of Agriculture.

The New Brunswick Department of Agriculture also made an appeal to the Canada Department of Agriculture for assistance on the reclamation of dykelands.

As a result of these reports and appeals a meeting was called by Dr. E. S. Archibald, Director, Experimental Farms, at Amherst, Nova Scotia on September 10 and 11, 1943, of dykeland owners, agricultural officials and engineers, for the purpose of reviewing the whole situation and deciding, if possible, on a definite line of action.

Following a discussion of methods and machinery for dyke construction, as well as for cleaning all drainage ditches and creeks, it was decided that a complete survey should be made and a report prepared on the work that should be undertaken and an estimated cost on any construction work that might be undertaken at a later date.

Data presented aι the meeting showed comparative maintenance costs for the periods previous to 1930 and from 1930 to 1945. These figures follow:

Hand Labor	1900-1930	1930-1945
Cutting new dale ditches (small) per brace*	10¢	15¢
Cutting new dale ditches (large) " "	15¢	30¢
Cleaning small dale ditches per brace	5¢	10¢
Cleaning large dale ditches per brace	10¢	20¢
Dyke construction 2' top, 6' high, 15' base, per brace	$2.85	$5.50
Dyke maintenance, average, per brace	.80	1.25
Aboiteaux construction (range of cost)	$200 to 10,000	$500 to 20,000

* - a brace = 6 feet in length

The average number of brace of small ditches per acre	117	or	(702')
The average number of brace of large ditches per acre	13	or	(78')
The ratio of dyke per acre was 4 brace		or	(24')

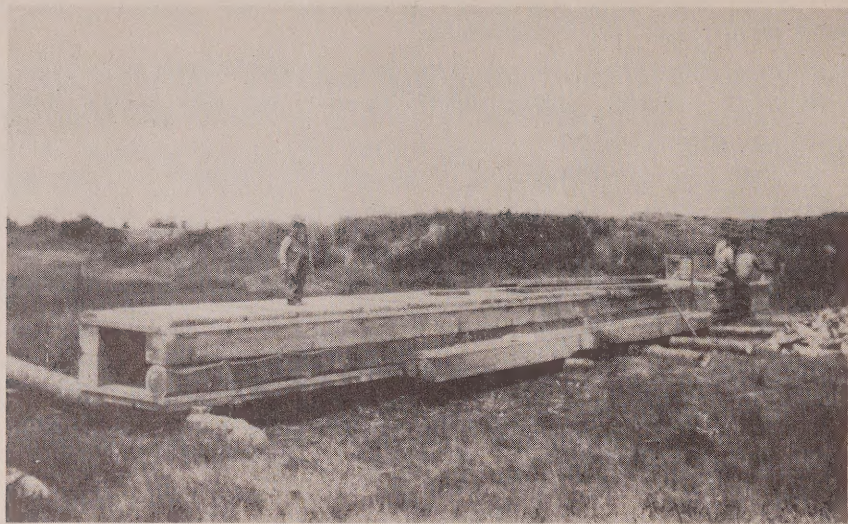


Fig. 1. A sluice having the finishing touch put on before being launched into position in an aboiteau.

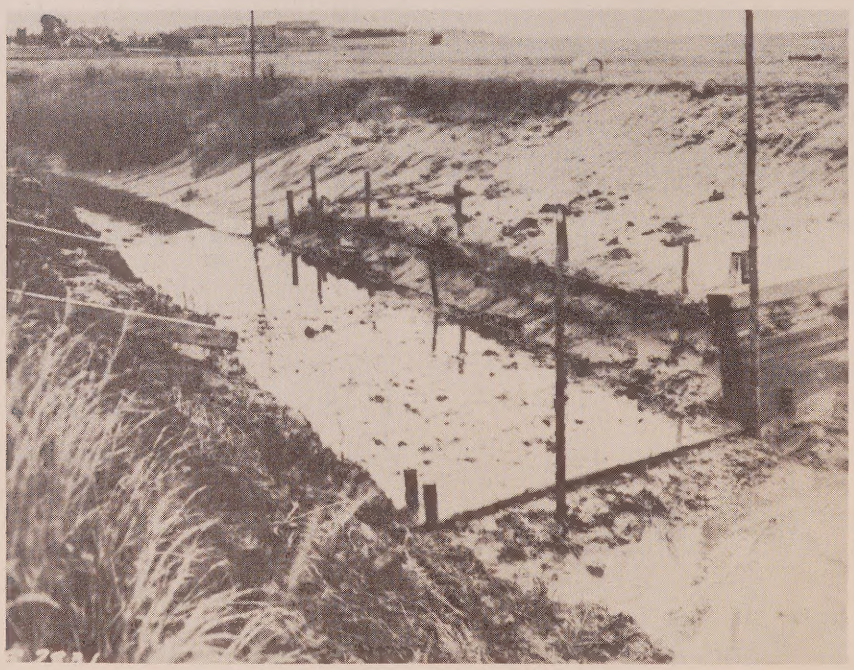


Fig. 2. Preparation of sluice bed. It was uniformly firm and level.

The meeting agreed that the rehabilitation of these dykelands offered an important field of study and it was recommended that a standing committee be appointed to be known as the Maritime Dykeland Rehabilitation Committee. This Committee would consist of four representative dykeland owners, four engineers, (two from each of the Provinces of Nova Scotia and New Brunswick), one soil specialist and one other official to be named by the Federal Deputy Minister of Agriculture. The duties outlined for this Gommittee were:-

(a) To consolidate all present information on each dykeland and where such is not available, to institute a survey as required.

(b) To examine each body and report on those worthy of reclamation and to study conditions of dykes, aboiteaux and drains on all bodies.

(c) To start experimental projects by hiring machines and labor, thereby providing important information on suitable types of machinery to be used.

(d) To secure legal services to study and consolidate all legislation dealing with dykeland acts and to draft new legislation as required.

(e) To prepare estimates on cost of all types of dyking and of minor and major drainage projects required.

(f) To recommend a policy for contributions by Federal and Provincial Governments and private owners both as to original cost and as to maintenance cost.

It was further agreed that since the main problem of dykeland reclamation in all areas is basic and similar, it should be treated as a single project, but because such varied areas are involved, regional representation should be made to the Standing Committee. Dykeland owners were to nominate the regional committee who would be consulted by the standing committee when it was considered necessary.

It was further agreed that the Standing Committee should obtain the advice of Messrs. Ben Russell and L. B. Thomson of the P. F. R. A. both having been associated with the reclamation work in Western Canada.

The following were nominated by the dykeland owners present, to act as regional committee men.

C. W. Fickes, Annapolis County, N. S.
O. A. Elderkin, Kings County, N. S.
M. C. Hansen, Hants County, N. S.
Purley Lorraine, Colchester County, N. S.
Charles Logan, Cumberland County, N. S.
S. R. Colpitts, Albert County, N. B.
D. C. Harper, Westmorland County, N. B.

Fig. 3. Preparation for the launching of a sluice.

Fig. 4. The sluice being floated into position.

Fig. 5. Shows a break in the dyke which, if not repaired immediately, will cause untold damage and waste.

Fig. 6. This picture illustrates what will happen if the dykes are not repaired immediately following a break. Note the deep gully cut by the receding tides.

On representation from this meeting, the three Governments nominated the following men as a Standing Committee:

Engineers

Prof. Angus Banting, Agricultural College, Truro, N.S.
J. E. Belliveau, Department of Highways, Halifax, N.S.
Arnold Roberts, Department of Agriculture, Fredericton, N.B.
Donald Oxley, Department of Highways, Sussex, N.B.

Dykeland Owners

Charles T. Logan, Amherst Point, N.S.
LeBaron Troop, Annapolis, N.S.
Ormond Calhoun, Albert Co., N.B.
Donald C. Harper, Sackville, N.B.

Government Representatives

Dr. George Smith, Agricultural College, Truro, N.S.
W.W. Baird, Experimental Farm, Nappan, N.S.

This Committee had its first meeting on October 8, 1943 at Amherst, Nova Scotia. At this meeting W.W. Baird, Superintendent of the Experimental Farm, Nappan was appointed Chairman and Dr. George Smith Secretary.

Through Dr. E.S. Archibald, Director of Experimental Farms, the sum of $10,000 was procured to carry out the preliminary survey of these dykelands and 35 men were secured from the universities in the Maritimes during the fall of 1943. These were organized into two groups, one operating from Sackville, N.B. and the other from Amherst, N.S. and they began the survey on September 20, 1943. J.A. Roberts was in charge of the New Brunswick group and J.W. Byers the Nova Scotia group.

The weather was most unfavorable, rain fell on nine days of the eighteen on survey. The New Brunswick group reported that some 14,000 acres had been covered on control work and that this was tied in with the work of the Amherst group. The Nova Scotia group reported on some 2,000 acres of plane-table work and stated that contours at 1 foot per inch had been completed at a cost of $1.30 per acre.

These cost figures on contour work were much higher than average due to the fact the men had to be billeted at hotels in place of regular boarding houses. Normally contour work can be carried out at a cost of from 30 to 50 cents per acre. On advice of Mr. B. Russell it was decided to make as complete a survey as possible of all areas or Bodies on which construction work was to be carried out.

In view of this, the Committee recommended that:

(1) An engineering office be established and located, for the present, at the Experimental Farm, Nappan, N.S.

(2) Messrs. Byers and Roberts, with whatever help was available, try and complete one or more project areas on which emergency repairs might be carried out the following year.

(3) During the winter months they work up data on at least two construction programs.

(4) All available data on any previous surveys that may have been made be completed.

(5) Instruments for stream flow, be located and points of study outlined.

(6) Machinery available for dyke and drainage work be located and procured.

(7) Types and sizes of dykes for specific areas be studied.

(8) Study be given to the effect of breakwaters and to river and cannal currents to determine where breakwaters should be constructed.

(9) Types and sizes of ditches best suited for internal body drainage and for main vents be studied.

(10) Feasibility of using tiles with and without boards underneath them be investigated and the amount required per acre of land determined.

(11) Projects be outlined and classified into those that require immediate attention and those for later action.

(12) Consideration be given to the feasibility of the Government taking over 1,000 acres of dykeland at a central point solely for experimental purposes.

(13) Grazing of dykelands and its effect on drainage be studied.

(14) Economic rehabilitation of broadleaf areas be studied.

Emergency work

From 1943 to 1947 emergency work on all dykelands throughout the Maritimes was carried out under the direction and supervision of the Superintendent of the Canada Experimental Farm, Nappan, N.S. and his staff.

During the past ten or fifteen years the loss caused by the breaking of dykes and aboiteaux has been extremely heavy. Losses were not confined to the cost of rebuilding the dykes and aboiteaux but damage to crops, bridges, highways and buildings would run into thousands of dollars.

These losses have placed a tremendous burden on the landowners; more than the average landowner could bear. Following a careful study of prevailing conditions, it was recommended that the Federal Government should co-operate with the Provincial Governments to assist the landowners in protecting these areas from further loss of crops and land.

An agreement was reached late in 1943 whereby the Federal and Provincial Governments and the landowner would each assume one-third of the cost of all emergency repair work. The main objective was to conserve feed for livestock and, in addition, to record data on the use and cost of the different types and makes of

machines for the construction of dykes and aboiteaux.

Late in the fall of 1943, a survey of some 5,500 acres of dykeland in the Amherst and Aulac districts, was made. Contouring was done to 1-foot intervals and plans drawn on a scale of 1-inch to 400 feet. This survey did not show property lines which should be shown for a complete survey. The cost of control ranged from \$0.18 to \$0.20 per acre; plane tabling cost \$0.15 to \$0.18 and office work \$0.05 per acre, or an average total of \$0.40 per acre. A survey was made of all work projects carried out from 1943 to 1947. The cubic yards of earth and brush were recorded for each work project and the cost per cubic yard in place was calculated. These data are on file at Nappan.

During 1946, a reconnaisance survey was made of some 26 miles of dykes and aboiteaux in Nova Scotia and 21 miles in New Brunswick, the object being to determine the average repairs necessary per mile of dyke. The cost of the survey (with inexperienced help), was \$40 per mile, or an average of \$0.28 per acre of land protected.

This survey revealed that 75 per cent of the average dyke would pass as reasonably safe, 18 per cent required heavy reinforcing and 7 per cent required immediate replacement. These appraisals were based on previous standards. Under present-day standards, not more than 25 per cent of the dyke could be considered safe, 50 per cent should be heavily reinforced and 25 per cent replaced. The previous standard for handbuilt dykes was a 12 to 15 foot base, 5 to 10 feet high and a 2 foot top. The standard recommended for machine-constructed dykes is a 30 to 40 foot base, 6 to 10 feet high and a 4 foot top. The sea side slope should be 1 to 3 with the borrow pit not less than 150 feet from the base of the dyke.

In 1944, when the repair work began, very few machines were available. In fact, one 3/4 cubic yard dragline and two D-4 bulldozers were the only machines obtainable.

There were 80 work projects carried out in Nova Scotia from 1944 to 1947. Of these, Canning aboiteau was treated as a special case. The other 79 were on the 1/3 payment basis. These projects covered a distance of 81,700 feet of dyke and aboiteaux, and required 225,100 cubic yards of earth and brush fill. (This includes reinforcing work as well as new dyke construction). The gross cost was \$220,633.71, an average of \$0.87 per cubic yard, or \$7.05 per acre of land protected.

The Canning aboiteau is one of the largest ever built in Eastern Canada and one of the first to have the sluice built on piling. The sluice is 120 feet long, with three waterways, 3 feet by 5 feet each, inside measurements, and it required approximately 50 thousand feet of hardwood timber to construct the sluice. The fill required 72,400 cubic feet of rock, earth and brush. The total cost of construction was \$234,631.93 or \$3.24 per cubic yard of fill, including sluice.

There were 50 work projects carried out in New Brunswick during the same period. These covered a distance of 62,700 feet of dykes and aboiteaux. The quantity of fill required was 134,500 cubic yards of earth and brush. The total cost

was $137,206.01, or an average cost of $0.95 per cubic yard of fill in place, or $5.52 per acre of land protected.

The total of the dykes, aboiteaux and drainage canals constructed in the two provinces was 27.6 miles. This included a drainage cannal 11,643 feet in length. The volume of excavation (canal) was 32,135 cubic yards at an average cost of $0.30 per cubic yard.

Prior to 1944, no data were available on the cost of machine-built dykes, with the exception of one pioneer undertaking carried out by the Grand Pré Body, N.S. This Body built about 1,600 feet of good dyke with a 3/4 cubic yard dragline. Since 1944, the dragline and bulldozer have been used on all major construction work on dykes and aboiteaux. The bulldozer does excellent work on firm soil, but is not efficient on very soft ground. The average unit cost per cubic yard of earth moved by bulldozer was $0.28, (range $0.15 to $0.80); for dragline, $0.50 per cubic yard, (with a range of $0.17 to $1.09), on dyke work. The bulldozer has an advantage over the dragline on firm soil, but this is not so on soft ground. By using mats, the dragline can be used on very soft land. The main objection to dragline work is that it leaves the borrow pit too close to the base of the dyke. When bulldozers are used the borrow pit need not be nearer than 150 feet to the base of the dyke. The data collected indicated that it is not economical to move earth by bulldozer more than 200 to 250 feet. Both the bulldozer and the dragline have a place in dyke construction and may be used economically. For small jobs, on firm ground, a D-4 bulldozer will do a very satisfactory job, but for general all-round work, the D-6 with wide treads will do the work at a lower unit cost.

On small to medium size jobs, where the ground is soft and frequent moves are necessary, a 1/2 to 3/4 yard dragline was found preferable. On dykeland that has been out to tide, yet has reasonably firm ground conditions, a 3/4 to 1 yard dragline will handle the earth at less cost. On large work projects, where ground is not too soft and long moves are not necessary, the 1 to 1 1/2 cubic yard machine is preferable.

To date no very satisfactory machine has been found to handle the mud on aboiteaux efficiently and economically. Where it can be operated successfully the bulldozer will place the earth over the brush on an aboiteau as efficiently as any machine thus far tested. On large aboiteau projects it may be found expedient to use both dragline and bulldozer. The real efficiency of either of these machines depends largely on the ability of the operator. With a good operator, it is possible to double the cubic yardage handled per operating hour. Like skilled dykemen, skilled operators are difficult to locate. This shortage of skilled operators made it more difficult to obtain fair comparisons between types of machines working under similar conditions. Nevertheless, valuable data have been compiled that should serve as a useful guide in any future work to be undertaken.

The unit cost was high in most of the emergency work carried out, mainly for the following reasons:

(1) Shortage of good machines, (bulldozers or draglines).

(2) Shortage of experienced operators.

(3) Rental charges at their peak.

(4) Frequent long moves of heavy machines necessary.

(5) Loss of time caused by high tides and storms.

(6) Low weight capacity of highway bridges, necessitating long, roundabout transportation moves by train.

(7) Lateness of season in which the major part of the emergency work had to be undertaken.

(8) About 50 per cent of the work had to be done on badly flooded areas.

(9) The scarcity of skilled foremen for aboiteau construction.

Very few skilled men under 65 years of age were available.

DYKELAND INVESTIGATIONS ON THE EXPERIMENTAL FARM, NAPPAN

There were approximately 70 acres of dykeland included in the original property purchased for the Experimental Farm, Nappan. This is bounded on the southwest by the Maccan River and northeast by the Nappan River.

Previous to 1917 the area was laid off in narrow dales and each dale plowed in two and sometimes three ridges. In 1918 plans were drawn up to carry out cultural and fertilizer tests on the dykelands. Before doing so it was considered advisable to reconstruct the whole area; that is, to lay it off in wider dales thereby reducing the drainage ditches and at the same time increasing the cultivated area. This work began in 1918 and finished in 1931. As soon as an area was ready for cultivation the land was prepared and soil fertility studies were started. The first project was laid down in 1922 and the last in 1931. Each plot was a whole dale or flat, approximately one acre in size.

The data submitted in this report first give a brief review of the analysis of the soil found on the principal dykeland areas of Nova Scotia and at the Experimental Farm, Nappan. This is followed by tables giving a summary of the average results obtained for the period of years each series of plots has been under study. These tables begin with the 1922 series and are followed consecutively through succeeding years.

While different soil types may be found on these dykelands, the soil in general is made up of 0-40 per cent of clay, 45-85 per cent silt and 15 per cent of sand. Through the courtesy of the Provincial Chemist, Truro, Nova Scotia, analyses of dykeland soils taken from a few of the more important areas in Nova Scotia were made available. These analyses are typical of the general dykeland areas. The exceptions to these will be found in Yarmouth County and inland at the extreme boundaries of a few of the larger tracts located in Cumberland and Westmorland Counties.

Fig. 7. Grain yields of from 50 to 75 bushels per acre are harvested off dykelands in average years.

Fig. 8. Yields from 2 to 3 tons of hay are cut from dykelands that are limed and well drained.

From a review of the analyses of 21 upland samples taken from various soil associations of Cumberland, Colchester, Hants and Pictou counties as compared with some 15 dykeland samples taken from the same counties the same year, and averaging the results of each, the following deductions were made:

(1) Surface dykeland and upland soils are on the average about equal in organic matter, total nitrogen content and available calcium.

(2) The CaO and MgO in the average dykeland surface soil are about double that of surface upland soils that have not been limed.

(3) The exchangeable or available Mg and K range from two to five times higher in dykeland soils.

(4) The available P is very little higher in dykeland surfaces soils than in replaced soils, when the pH is low. However, the availability of this element in dykeland soils is directly proportional to the pH and where the pH is high or is raised by liming, a very large increase in available P is developed.

(5) Apart from the obvious superiority of the surface dykeland soils over upland soils in plant nutrients, dykeland soils have two other advantages. Most upland soils contain higher quantities of plant nutrients in the cultivated layer than in the subsoil until the parent material is reached at from two to three feet in depth. Unless a plant is very deep rooted, it must extract most of its nutrients from the cultivated layer. Dykeland soils usually increase in plant nutrients with depth and hence are capable of supplying many times as much plant food as the upland soils.

Fig. 9. Over a period of 29 years 1 1/2 tons and 2 1/2 tons of limestone applied every 6 years have given a crop increase valued at $30. and $20. per ton of lime respectively.

Table 1 - Chemical and physical analysis of dykeland soils of Nova Scotia

Series & Soil Class	Location	Depth in Inches	Loss on Ignit-ion %	pH	Lime Req. Tons/ Acre	Total N %	Total Si02 %	Total R203 %	Total Ca0 %	Total Mg0 %	Exchangeable Bases Me/100 gms. of Soil: H	Ca.	Mg.	K	Na.	Avail. P lbs./ Acre	Gravel %	Sand 2-.05 mm. %	Silt .05-.002 mm. %	Clay below .002 mm. %
			Chemical Analysis														Physical Analysis			
1 A	Amherst Cumb.	0-6	7.99	4.80	5.6	0.24	64.41	23.69	0.57	1.51	9.57	2.78	3.28	0.32	0.67	80	0	15.2	60.4	24.6
		6-12	4.91	5.62	3.9	0.13	66.03	29.45	0.56	1.12	5.06	2.64	5.55	0.21	1.47	158	0	12.2	57.2	30.6
		12-18	3.66	7.07	0.0	0.09	67.60	26.13	0.67	1.59	0.00	2.53	6.33	0.29	3.06	297	0	13.4	60.2	26.4
		18-30	2.75	7.92	0.0	0.06	69.69	25.05	0.70	1.64	0.00	1.94	5.28	0.56	4.09	317	0	13.4	58.6	28.0
1 A	Truro Col.	0-8	6.33	5.48	2.4	0.22	68.55	23.03	0.74	1.15	5.40	8.33	2.22	0.36	0.15	129	0	19.6	61.6	18.8
		8-16	3.57	5.70	1.7	0.09	70.67	25.21	0.74	1.03	2.97	7.28	2.17	0.24	0.18	222	0	16.8	62.8	20.4
		16-24	2.02	7.12	0.0	0.05	76.62	17.98	0.97	1.09	0.00	9.78	0.67	0.20	0.22	246	0	25.2	64.4	10.4
		24-30	1.65	7.55	0.0	0.04	74.38	18.96	1.27	1.28	0.00	15.00	0.67	0.25	0.25	246	0	27.4	61.6	11.0
1 B	Grand Pre, Kings	0-8	5.63	5.76	2.1	0.15	63.89	24.07	0.53	1.50	5.33	3.55	5.00	0.31	1.13	137	0	20.6	52.2	27.2
		8-16	4.89	5.32	2.1	0.09	61.89	29.26	0.43	1.97	4.73	3.14	7.39	0.69	2.81	154	0	10.0	48.0	42.0
		16-24	4.13	4.88	3.9	0.09	61.63	29.42	0.41	1.97	6.10	2.67	6.44	0.84	2.72	58	0	12.6	47.2	40.2
1 B	Canning Kings	0-8	5.28	5.91	1.7	0.14	65.49	27.17	0.52	1.63	4.70	1.95	2.78	0.97	5.31	186	0	17.8	48.0	34.2
		8-16	5.10	5.45	1.7	0.12	65.08	25.07	0.43	1.87	4.20	1.70	2.56	1.01	7.35	124	0	16.8	47.6	35.6
		16-24	4.51	4.94	3.5	0.10	66.68	25.54	0.46	1.60	4.87	1.55	2.33	0.92	6.95	46	0	21.2	44.2	34.6
2 B	Truro Col.	0-6	8.56	4.76	6.3	0.29	65.26	21.03	0.48	1.58	8.93	2.17	3.94	0.22	3.18	18	0	21.8	59.0	19.2
		6-12	5.63	4.55	4.2	0.17	67.62	20.69	0.49	1.57	5.82	2.33	4.39	0.20	4.30	30	0	19.8	59.6	20.6
		12.28	3.45	4.00	4.6	0.11	68.21	22.21	0.47	1.49	6.59	1.56	3.39	0.24	2.09	21	0	17.8	50.4	21.8
		28 plus	11.64	3.82	11.3	0.37	58.59	25.08	0.34	1.62	14.98	2.39	5.28	0.67	6.47	32	0	16.0	55.8	28.2
2 C	Brooklyn Hants	0-7	7.37	4.82	3.1	0.21	61.39	23.50	0.42	1.06	6.17	3.14	7.17	1.28	14.30	182	0	12.4	59.0	28.6
		7-14	5.81	4.13	4.6	0.27	63.82	21.86	0.42	0.99	7.57	2.22	5.39	0.96	10.58	46	0	15.6	57.6	26.8
		14-22	5.20	3.89	4.9	0.14	62.92	25.10	0.41	1.21	8.20	2.39	6.17	1.13	12.26	28	0	11.6	53.6	34.8
		22 plus	9.42	4.21	6.3	0.25	55.05	29.23	0.32	0.98	10.07	3.28	8.28	1.68	18.89	76	0	9.6	43.6	46.8

Table 2 - Chemical and physical analysis of dykeland soils of Nova Scotia (continued)

Series & Soil Class	Location	Depth in Inches	Loss on Ignition %	pH	Lime Req. Tons/Acre	Total N %	Total Si02 %	Total R203 %	Total Ca0 %	Total Mg0 %	Exchangeable Bases Me/100 gms. of Soil H	Ca.	Mg.	K	Na.	Avail. P lb./Acre	Gravel %	Sand 2-.05 mm. %	Silt .05-.002 mm. %	Clay below .002 mm. %
3 B	Pre Rond	0-10	7.10	5.60	2.8	0.23	65.82	18.39	0.95	1.22	6.73	8.50	2.33	0.24	0.26	86	0	17.2	63.0	19.8
	Anna. Co.	10-24	5.79	5.08	6.0	0.16	64.41	26.17	0.52	1.57	9.67	2.39	3.50	0.33	0.33	18	0	10.4	53.8	35.8
3 C	Falmouth	0-8	10.22	4.93	8.8	0.30	59.99	24.94	0.34	1.43	11.71	2.44	2.56	0.25	1.04	8	0	20.8	54.6	24.6
	Hants	8-16	6.05	4.58	9.8	0.16	62.47	25.09	0.34	1.58	12.19	1.33	2.72	0.34	1.78	4	0	11.2	52.2	36.6
		16-24	7.07	4.32	8.8	0.17	60.46	25.26	0.32	1.47	14.03	1.19	2.61	0.61	1.26	10	0	12.8	44.6	42.6
4C	Amherst	0-6	45.66	4.56	---	1.34	29.35	21.99	0.32	1.13	39.60	3.54	6.32	1.17	----	6	-	----	----	----
	Cumb. Co.	6-12	8.42	4.26	6.7	0.21	58.86	30.24	0.34	1.95	10.11	2.28	8.39	0.82	6.51	18	0	14.4	41.8	43.8
Stewiacke	Col.	0-6	8.88	5.09	7.4	0.19	63.39	24.92	0.15	0.69	15.58	4.06	0.44	0.08	----	2	0	25.8	41.0	13.2
Stewiacke	Hants	0-6	5.43	5.33	3.1	0.16	73.08	16.30	0.42	0.88	4.83	4.72	0.83	0.11	----	32	0	22.0	64.2	13.8

Table 3 - Chemical and physical analysis of dykeland soils at the Experimental Station, Nappan under treatments of lime and fertilizer. 1950.

Treatment per acre	Depth in Inches	Loss on Ignition %	pH	Lime Req. Tons/Acre	Total N %	Total Si02 %	Total R203 %	Total Ca0 %	Total Mg0 %	Exchangeable Bases Me/100 gms. of Soil: H	Ca.	Mg.	K	Na.	Avail. P lb./Acre	Gravel %	Sand 2-.05 mm. %	Silt .05-.002 mm. %	Clay below .002 mm. %
Lime 2 1/2 tons	0-6	7.99	5.98	1.0	0.25	61.80	23.91	0.73	1.92	2.78	8.61	6.55	0.45	0.47	116	0	15.4	51.8	32.8
Lime 1 1/2 tons	0-6	7.87	5.14	2.4	0.21	60.81	26.19	0.54	1.90	4.88	5.67	6.67	0.37	0.40	100	0	13.4	51.8	34.8
Wood Ashes 1400 lbs.	0-6	7.78	4.80	3.5	0.27	62.48	25.10	0.54	1.84	6.96	3.03	5.55	0.43	0.71	62	0	14.4	54.1	31.5
Nil	0-6	7.59	4.62	4.6	0.24	62.38	25.08	0.51	1.77	8.96	1.92	4.84	0.61	0.76	34	0	14.4	51.5	34.1
Lime 2 1/2 tons 400 lb. 5-15-6	0-6	8.37	5.50	2.8	0.28	62.36	26.63	0.66	1.68	6.78	8.56	4.06	0.46	0.38	85	0	15.1	55.8	29.1
Lime 2 1/2 tons	0-6	7.70	6.72	0.7	0.25	64.40	23.57	0.76	1.59	1.42	10.33	5.50	0.42	1.27	182	0	16.4	56.5	27.1
Nil	0-6	6.07	4.80	4.9	0.22	70.70	19.03	0.61	1.35	8.64	1.17	2.89	0.36	0.65	36	0	23.4	61.5	15.1

Chemical Analysis: Treatment through Avail. P. Physical Analysis: Gravel through Clay.

The relatively unweathered silts in dykeland soils are capable of releasing plant nutrients to the colloid complex as they are removed by cropping and by leaching.

Highly weathered primary minerals of upland soils have already lost much of their nutrient elements through the podzolization processes and hence are incapable of replacing plant nutrients lost through cropping and by leaching.

It is interesting to note the relatively high available phosphorus content of these soils and the correlation between the pH value and available phosphorus.

Dykeland soils highly fertile

The comparative chemical analysis of upland versus dykeland soils, taken at the Experimental Farm, Nappan, will be found in the following table:-

Table 4 - Dykeland and upland soil analysis, Nappan

Kind of Soil	Depth of Sample	pH	N %	Organic Matter %	Soluble P205 p. p. m.	CaCo %	Exchangeable Magnesium %	Exchangeable K %	Exchangeable Manganese p. p. m.
Upland	0-6"	5.45	0.230	7.08	136	0.127	0.043	0.007	22.2
"	6-12"	5.11	0.089	3.34	106	0.234	0.014	0.003	----
Dykeland	0-6"	5.64	0.192	5.30	135	0.059	0.169	0.014	24.5
"	6-12"	5.45	0.112	3.45	213	0.086	0.169	0.021	----

The upland tests show the layer below plow depth to be somewhat lower in mineral elements than the top six inches. The dykeland soil shows a reserve of these elements at the 6-12" depth. The dykeland surface soils have a higher magnesium and potash content than the upland, while the nitrogen, phosphorus and manganese content is about the same. The dykeland shows a lower lime content than the upland in the top 6 inches of soil. The significant point throughout in this table is that after years of cropping without added fertility the dykeland soil still shows as much available plant food as the upland soil which has received regular fertilization every four to five years.

Dykeland produces hay of high quality

The comparative chemical analysis of upland and dykeland hay cut at Nappan on the same day is recorded in Table 5:-

Table 5 - Analysis of hay grown on dykeland and upland soils, Nappan

Crop	Where Grown	Chemical Analysis			
		Moisture %	Protein %	Fibre %	Ash %
Timothy	Upland	4.65	5.17	35.07	4.21
"	Dykeland	4.84	6.05	35.51	6.65
Couch grass	Upland	4.67	6.76	30.71	3.79
" "	Dykeland	4.87	6.58	31.37	6.03
Common red clover	Upland	5.68	13.86	29.53	6.95
Common red clover	Dykeland	5.74	15.53	26.40	7.88

The average of the three dykeland species is 0.8 per cent higher in protein and 1.87 per cent in ash than that of the same three species cut from the upland. The clover cut from the dykeland is 1.67 per cent higher in protein than the clover cut from the upland. All other things being equal, the hay cut from dykeland is of higher feed value than that cut from the upland.

Lime gives large returns

In 1922 a trial was started to study the value of ground limestone on dykeland soils.

Over a period of 29 years 1 1/2 tons and 2 1/2 tons of limestone applied every 6 years have given a crop increase valued at $30. and $20. per ton of lime respectively.

Table 6 - Ground limestone for dykeland soils, Nappan, 29 year av., 1922-1950 incl.

Treatment	Crop	Yield per Acre	Annual Net Return per acre
			$
Check. No fertilization	Oats Straw Hay	28.50 Bu. .66 Tons 1.91 Tons	20.05
2 1/2 tons ground limestone applied, 1922-29-34-40-46	Oats Straw Hay	43.7 Bu. 1.10 Tons 2.76 Tons	28.64
1 1/2 tons limestone applied in 1922-29-34-40-46.	Oats Straw Hay	45.5 Bu. .98 Tons 2.63 Tons	27.68

All treatments showed a significant increase over the untreated plots.

The net returns obtained over the 29-year period have been about $20 per ton of lime applied for the 2 1/2 ton rate and about $30 per ton for the 1 1/2 ton rate.

Superphosphate and lime are of value on dykeland soils

In 1936 a trial was started to study the dykeland response to an application of superphosphate versus superphosphate plus lime in a three-year rotation.

Table 7 - Superphosphate and limestone for dykeland soils, Nappan, 16 year av., 1936-51 incl.

Treatment	Crop	Yield per Acre	Annual Net Return per acre $
250 pounds superphosphate years 1936-39-42-45-48-51	Oats Straw Hay	40.1 Bu. 1.12 Tons 2.40 Tons	30.89
250 pounds superphosphate plus 1500 pounds limestone in the same years	Oats Straw Hay	53.8 Bu. 1.15 Tons 2.98 Tons	37.58
No treatment	Oats Straw Hay	30.0 Bu. .76 Tons 2.25 Tons	26.50
1500 pounds limestone 1936-39-42-48-51	Oats Straw Hay	41.3 Bu. 1.14 Tons 2.73 Tons	34.12

All treatments were significantly better than the untreated plot. The results following treatment with limestone are very marked. The average return from 250 pounds of superphosphate over check per 100 pounds applied was $6.64, or for every dollar invested in superphosphate there was a return value in increased crop of $3.81. For limestone the increased crop return value was $33.52 per ton applied, or, in other words, for every dollar invested in limestone, the return was $11.00.

Manure and fertilizer improves hay quality and yield

In 1923 a project was initiated to study the response of dykeland soil to an application of barnyard manure versus commercial fertilizer when applied as a top dressing to a permanent grassland area. The results are given in the following table:-

Table 8 - Manure vs. chemical fertilizer for hay production on dykeland, Nappan, 26 year av., 1923-1948 incl.

Treatment	Crop	Yield per acre	Annual Net Return per acre $
Manure 8 tons every 4 years	Hay	2.45 Tons	22.96
Fertilizer annually. Spring application 50 lb. ammonium nitrate plus 120 lb. superphosphate plus 60 lb. ground limestone	Hay	2.59 Tons	24.71
No treatment	Hay	1.86 Tons	20.37

All treated plots gave decidedly better yields than did that which received no treatment and the quality of hay was definitely superior.

In this test each ton of manure applied gave a return value in increased crop yields of $3.01. Each dollar's worth of manure returned $2.01 in increased crop values. In the case of the fertilizer each dollar's worth applied returned $2.15 in increased crop value.

Slag and wood ashes are valuable

This test covered seven dales and compared the relative response of dykeland soil to two types of slag, wood ashes and ground limestone. All dales were in hay over the entire period.

This test was discontinued after data for six years had been collected.

Table 9 - English slag vs. wood ashes, vs. 14% slag vs. limestone for hay production on dykeland, Nappan, 6 year av., 1925-1930 incl.

Treatment	Crop	Average Yield	Annual Net Return per acre $
1200 lb. English slag 16% applied in 1924	Hay	2.80	28.73
1400 lb. wood ashes per acre applied in 1924	Hay	2.28	23.96
Check - no treatment	Hay	1.90	20.30
1400 lb. 14% slag per acre applied in 1924	Hay	2.35	23.96
4000 lb. ground limestone per acre applied in 1924	Hay	2.31	23.60

All treatments were significantly better than the check plot. The 16% English slag gave an increased crop value of $4.87 over the average of the 14% slag, with approximately the same amount of P_2O_5 being applied, 192 and 196 pounds respectively. The 1400 pounds of wood ashes gave returns equal to those of the 1400 pounds of 14% slag when applied in the spring as a top dressing on grassland.

The hay cut from the treated plots has always been superior in quality to that taken from the check plots.

Fig. 10. The 7 year average grain yield was 53.7 bushels and the 15 year average hay yield was 2.5 tons. This dale was treated with manure and limestone.

Fig. 11. 7 year average grain yield has been 30.1 bushels and 20 year average hay yield 1.93 tons, for the plot on the left which has received no treatment. The plot on the right had a 7 year average grain yield of 37.5 bushels and a 20 year average yield of 2.72 tons of hay. This plot received commercial fertilizer.

Lime and fertilizer gives increased yields in eight-year rotation

In 1925 a trial was started to permit a study of lime and fertilizer response on dykeland soil in an eight-year rotation. The test comprised six one-acre dales. The treatments, shown in the table, were applied once every eight years.

The average results obtained over the 27-year period are submitted in the following table:-

Table 10 - Lime and fertilizer for eight-year rotation on dykeland, Nappan, 27 year av., 1925-1951 incl.

Treatment	Crop	Yield per Acre	Annual Net Return per acre $
Check	Oats	35.2 Bu.	
	Straw	.78 Tons	19.47
	Hay	1.66 Tons	
2 1/2 tons limestone applied in 1925, 33-41-49.	Oats	49.9 Bu.	
	Straw	1.23 Tons	24.92
	Hay	2.22 Tons	
1 1/2 tons limestone applied in 1925-33-41-49.	Oats	43.8 Bu.	
	Straw	1.21 Tons	25.87
	Hay	2.31 Tons	
1000 lb. 16% slag applied in 1925 and -33; 800 lb. superphosphate applied 1941-49; 400 lb. limestone	Oats	46.20 Bu.	
	Straw	1.23 Tons	26.54
	Hay	2.43 Tons	
1400 lb. wood ashes 1925-33; 1 ton limestone 1941-49.	Oats	43.40 Bu.	
	Straw	1.12 Tons	25.12
	Hay	2.21 Tons	

The fertilized plots have shown significantly better yields than the checks. A major point is that the hay on the treated plots is much superior in quality to the hay taken from checks. Where 2 1/2 tons of limestone were applied the return crop value was $15.36 for each ton applied. Where 1 1/2 tons of limestone were applied the return crop value was $28.37 for each ton applied. In case of slag the value was $4.55 for each dollar's worth applied and for wood ashes and limestone $8.78 for each dollar's worth applied.

Figure 12 shows graphically the decrease in hay yields over the various years of the rotation.

Fig. 12

A - 2 1/2 tons ground limestone per acre

B - 1 1/2 tons ground limestone per acre

C - Check

Additional potash not necessary

In 1927 the field of study on the use of fertilizers on dykeland soil was extended. The original outline of the project covered some fifteen dales, but unfortunately during a heavy wind and rain storm the dykes broke and the greater part of the area was flooded several times. Consequently, 12 of the 15 dales were eliminated from the test on account of injury from salt water and salt deposits.

Table 11 shows average results for the three undamaged dales. These data cover a 21-year period.

Table 11 - Nitrogen and potash on dykelands, Nappan, 21 year av., 1927-47 incl.

Treatment	Crop	Average Yield per acre	Annual Net Return per acre $
50 lb. ammonium nitrate plus 120 lb. superphosphate and 60 lb. limestone applied each spring on the hay crop.	Oats Straw Hay	35.0 Bu. .84 Tons 2.67 Tons	27.13
Same as No. 1 plus 50 lb. muriate of potash applied each spring to hay crop.	Oats Straw Hay	34.60 Bu. .84 Tons 2.72 Tons	26.04
Check - no treatment	Oats Straw Hay	35.70 Bu. .93 Tons 1.98 Tons	22.80

As in the previous test, the topdressing with commercial fertilizer for hay proved satisfactory.

The addition of 50 pounds of muriate of potash in treatment 2 to the fertilizers of treatment 1, has resulted in a slight increase in hay yield and a slight decrease in oat yield. The end result has been that the net return was lower where the potash was applied as it cost more than offset the small increase in the crops. The indications are that for the present, applications of potash are not necessary on dykelands.

Fertilizer not necessary to bring broadleaf marsh into production

This trial is perhaps one of the most interesting of all the tests conducted on the dykeland, because the area was approximately three-quarters broadleaf when first broken in 1931. It was sown to oats and seeded in 1932, but nothing grew. Late in the summer of 1932 the whole area received an application of 16 tons of barnyard manure and was disked during the remainder of the season. In the spring of 1933 it was again disked several times and resown to oats and grass seed mixture.

Each treatment as shown in Table 12 was duplicated, and the average taken for the 19-year period.

Talbe 12 - Limestone and commercial fertilizer for old broadleaf marsh, Nappan, N. S., 19 year av., 1933-1952 incl.

Treatment	Crop	Average Annual Yield per acre	Annual Net Return per acre $
2 1/2 tons limestone per acre applied every 6 years.	Oats	33.90 Bu.	
	Straw	1.11 Tons	30.55
	Hay	2.77 Tons	
2 1/2 tons limestone plus 400 lb. 3-15-6 per acre.	Oats	34.40 Bu.	
	Straw	1.00 Tons	29.93
	Hay	2.68 Tons	
Check - no treatment	Oats	23.50 Bu.	
	Straw	1.06 Tons	21.47
	Hay	1.97 Tons	

The year's rotting of the sod together with the application of manure gave excellent results. The above data show an average return of $24.70 for each ton of limestone applied over the entire period of 19 years or a return of $9.57 for each dollar's worth of limestone applied. Where 400 pounds of fertilizer were added with the 2 1/2 tons of limestone, the return on a dollar invested was much lower, averaging only $3.65 for each dollar invested in lime and fertilizer. These results indicate that this type of soil has a high level of fertility.

Three- or four-year rotation most satisfactory

The general practice previous to 1910 was not to plow dykeland frequently. The majority of dykeland owners plowed only once in 15 to 25 years. The more progressive owners believed it should be plowed and reseeded every 10 to 15 years.

Table 13 contains comparative data on plowing and reseeding every three, four, and eight years.

Table 13 - The effect of frequency of plowing on dykeland hay yields

Treatment	Crop	Average Yield per Acre	No. of Crop Years
		Tons	
Plowed every three years. No other treatment	Hay	1.91	22
Not plowed since 1924	Hay	1.86	26
Plowed every four years. No other treatment.	Hay	1.93	20
Plowed every eight years. No other treatment.	Hay	1.73	23

There are no indications that frequent plowing would be detrimental to dykelands. In fact the data are slightly in favor of the shorter rotation. Either a three- or four-year rotation would appear to be most satisfactory, for not only does the yield show some increase but the hay from the more frequently plowed flats is of better quality since it contains a higher percentage of the more desirable species.

There is very definite indication that it is not profitable to leave dykelands down to hay longer than six years. It has been observed that not only does the yield drop after four to five years, but that there is a very definite drop in quality of hay.

Fig. 13. Following the application of 2 1/2 tons of limestone per acre applied every eight years, the average grain yield was 49.9 bushels. 1 1/2 tons - 43.8 bushels. No fertilization during the past forty years.

Fig. 14. Following an application of 2 1/2 tons of lime per acre every eight years, the average hay yield has been 2.22 tons. The 1 1/2 tons application of limestone has given an average of 2.31 tons.

Width of dale can vary considerably without any reduction in crop yields

Without any definitely planned test, a reasonably fair comparison can be made of the yields obtained from different widths of dales.

Table 14 gives the average yields of oats and hay taken from three different widths of dales.

Table 14 - Effect of width of dale on crop yields over a period of years

Width of dale	Average annual Yield per acre	
	Oats Bu.	Hay Tons
58 feet	30.9	2.00
68 "	31.0	2.04
75 "	33.0	1.89

There is no significant difference in the yields taken from dales of different widths. From the standpoint of cultural operations the wider dales facilitate the work to a very marked degree. With proper drainage even wider dales might be used, particularly if the dales are crowned. A project to study dales 50, 75, 100 and 150 feet in width is now in progress.

Dykeland makes good pasture

An experiment to compare the relative productivity and economy of dykeland and upland unimproved pasture was started in 1950.

Average results for two years are summarized in table 15:-

Table 15 - Upland versus dykeland pasture, 2 year average, Nappan, 1950-1951

	Upland	Dykeland
Area of field - acres	14.6	13.7
Kind of stock	Grade yearling steers	
Number of pasture days	112	112
Number of animal days	94.5	102.0
Average daily gain per head lb.	1.22	1.48
Corrected gain per acre lb.	142	165
Value of gain at $25. per 100 lb.	$35.01	$40.17
Yield of dried grass per acre lb.	2395	2752

Two years results are not sufficient to permit any definite deduction. However, the following points are of interest:

1) There was little difference in the total productivity from the two fields during the past two years. 2) The gains of the steers grazing on the upland fields decreased progressively as the season advanced, while the gains made by the steers grazing on the dykelands were very uniform throughout the season. 3) These results were the same for each of the grazing seasons.

These figures indicate that dykeland may be profitably utilized as grazing land, especially where good drinking water is available. This experiment was revised in 1952 in order to test the response of dykeland and upland pasture to applications of lime and lime plus superphosphate.

New dykeland investigations

Since the establishment of the Maritime Marshland Rehabilitation Administration, greater attention has been directed toward the study of wider dales and a more practical type of drainage; also to more profitable ways of utilizing these dykelands.

With these objectives in view the following studies have been started at Nappan:-

(1) Wide versus narrow dales, selecting a range of from 50 to 150 feet in width.

(2) Effect and efficiency of crowning dales versus the standard type type ditches for drainage.

(3) Heavy versus light crowning and their effect on drainage and the general effect on the operation of machinery.

(4) Dale construction in relationship to water tables.

(5) Utilization of dykelands for grazing.

(6) Floral growth on dykelands and on dykes in co-operation with the M. M. R. A.

The Construction of Protective Works

The four major factors in the successful operation of dykeland are: (1) good dykes; (2) good aboiteaux properly placed; (3) good drainage; (4) sound agronomic practices.

The size of the dykes will depend on the location of the Body and the exposure to heavy sea, or swift changing river currents. Dykes constructed by hand, sodded both sides, will vary from 8' to 15' base, 4' to 10' high and 1' to 2' top. When constructed by machines they range from a 20' to 40' base, 5' to 10' high and 4' to 6' top. In machine construction the outside slope should be not less than 1 to 3. On the larger dykes a 1 to 4 grade is preferable. The larger dykes with a good grade will give longer and more permanent protection at a lower maintenance cost. It is well to state that every Body presents an individual problem and due consideration must be given to the many factors that may have a detrimental effect on the type and size of dyke constructed.

In some cases it will be advisable to cut down on the size of dyke base, particularly, and face with plank or stone, in order to secure the greatest degree of safety. There are many cases where brush can be used to protect the base of the dykes and there are numerous cases where the lower banks require protection. In the latter case there is nothing better, to date, than brush matting, properly laid and well staked.

The practice of brush matting the lower banks to low-water levels has been followed at Nappan for the past forty years, with excellent results. In fact it has been used on many banks throughout the province with good results. In the construction of dykes where very soft mud has to be used, and for aboiteau construction, there has been nothing found to take the place of brush and stakes. This is particularly true from the standpoint of cost.

A further point to keep in mind is that a good sloping dyke on the inside will facilitate the cutting of grass and weeds right up to the top of the dyke by the use of a mower, thus saving many hours of laborious hand mowing.

In cases where an opportunity has been afforded to use upland soil with a fair portion of sand or gravel, it has proved to be superior to dykeland soil for dyke and aboiteau construction. The Canning aboiteau and dyke is an excellent example of the value of upland soil for construction work. There are indications that gravel may yet play an important part in the facing of dykes and aboiteaux.

The problem of when and where breakwaters should be used requires study. At the Experimental Farm, Nappan, several have been constructed during the past ten years and when properly placed on the river or basin banks they afford excellent protection. For the past fifty years or more brush and stake breakwaters with and without stones or mud, have been used for bank protection with excellent results. It is possible that large breakwaters may have a place, but in general they are too expensive. Small breakwaters, well built of brush, stakes, stone or mud have proved most effective. This Farm has built four breakwaters during the past ten years in order to gather some data on cost of construction and on the effectiveness of the protection given to banks and dykes.

The following data give the cost of building aboiteaux and breakwaters at the Experimental Farm, Nappan, during the past ten years.

Aboiteaux

A project was undertaken to study the cost, durability and efficiency of wood versus metal sluices in aboiteau construction. The procedure was to install three sluices, two metal - one two-foot and one three-foot - and one wooden sluice. One metal and one wooden sluice were installed during the fall of 1949 and one metal sluice was installed in the spring of 1950.

The metal sluices were built by the Armco Drainage Company of Guelph, Ontario. The following is a brief description of each of the sluices and the cost of installation.

No. 1 Sluice (metal) specifications

This metal sluice was 32 feet in length and consisted of 26 feet of 24-inch diameter 12-gauge corrugated iron pipe joined to 6 feet of 42-inch diameter 10-gauge corrugated iron pipe with a 24-inch cast steel flap gate hung at the intersection. A 10-foot by 6-foot corrugated metal headwall was also fitted at the outside end of the 42-inch pipe to form a porch. The entire sluice and fittings were asbestos bonded and asphalt coated at the factory in order to reduce salt water corrosion to the minimum.

No. 2 Sluice (metal) specifications

This metal sluice was 32 feet in length and consisted of 26 feet of 36-inch diameter 12-gauge corrugated iron pipe joined to 6 feet of 54-inch diameter 10-gauge corrugated iron pipe with a 36-inch cast steel flap gate hung at the intersection. A 10-foot by 6-foot corrugated metal headwall was also fitted at the outside

end of the 54-inch pipe to form a porch. The entire sluice and fittings were asbestos bonded and asphalt coated at the factory in order to reduce salt water corrosion to the minimum.

No. 3 Sluice (wooden) specifications

The sluice was 60 feet in length and 3' x 3'3" inside measurements. Constructed of creosoted timber, the sides and bottom were of 8-inch by 8-inch timbers. The top was two tiers of 4-inch by 8-inch plank lapped. Heavy marlin cord was laid along the centre between timbers. Timber end joints were broken by 8" x 1/4" iron plates set in centred grooves. All timbers were drawn tightly together by 5/8" bolts, threaded at both ends and fitted with nuts and washers. The gate for the sluice was made of three ply of 3/4-inch hardwood fastened together with brass screws. The gate was then bolted, with three large bolts, to a 2-inch round iron bar which was coated with 2/32 of an inch of bronze. Each end of the swinging bar turned in brass sleeves or bearings, which were secured on either side to the top timber. The shoulder against which the gate closes was lined with heavy rubber belting.

The following is a brief summary of the location and the cost of each aboiteau.

No. 1 Aboiteau

Located on a creek running between Charles Fullerton's and William Carter's dykelands, opening into the Maccan River. Classed as a very small aboiteau. The small 24" Armco metal sluice provides the waterway at that point. The water flow is never very heavy in this creek.

Cost Summary - No. 1

Metal sluice 24"	$ 738.82
Dragline 54 1/2 hours at $10.	545.00
Bulldozer 12 hours at $8.	96.00
Manual labor 170 hours at 60¢	102.00
Brush, 10 loads at $2.50	25.00
Stakes, 100 at 15¢	15.00
Miscellaneous cost, spikes, nails, etc.	10.00
	$1,531.82

The cubic contents of earth in fill was 1,012 cubic yards put in at a cost of $1.51 per cubic yard in place.

No. 2 Aboiteau

Located in a creek running between the Frank Roach and William Carter dykelands, opening into the Maccan River, is the larger 36" Armco metal sluice. The flow of water at this point is fairly heavy spring and fall. The spring is much heavier than the fall flow. This aboiteau would be classed as small to medium in size.

Cost Summary No. 2

Metal sluice 36"	$1,206.06
Dragline 67 hours at $10.	670.00
Bulldozer 106 hours at $8.	848.00
Labor 452 hours on aboiteau construction at 60¢	271.00
Labor 47 hours cutting brush at 60¢	28.20
Labor 114 hours brushing and staking old creek at 60¢	68.00
Tractors 33 hours, hauling brush and supplies at $1.00	33.00
Traxcavator 25 hours shovelling mud at $5.00	125.00
Trucks 107 hours hauling earth for roads	235.40
	$3,484.66

The cubic contents of fill in aboiteau was 800 cubic yards; connecting dykes on either side of aboiteau 875 cubic yards; total 1,675 cubic yards.

The cost per cubic yard of earth and brush in place was $2.08.

No. 3 Aboiteau

This aboiteau is located on a medium to large size creek which forms the boundary line between the Experimental Farm and Hallet Blenkhorn's dykeland.

The No. 3 creosoted wood sluice is located at this point.

During the spring and fall there is a heavy flow of water through this sluice into the Nappan River. Generally speaking the spring flow is much heavier than the fall run off.

Cost Summary - No. 3

Lumber for sluice	$ 735.00
Labor building sluice (carpenter)	435.20
" (blacksmith)	30.80
Hardware for sluice - bolts, plates, nuts, threading etc.	171.06
Creosote, 1 bbl.	44.10
Dragline, cleaning and filling, 120 hours at $10.	1,200.00
Bulldozer, filling and packing, 81 hours, at $8.	648.00
Brush, 1,200 pieces at 15¢	180.00
Trucking, 133 hours at $2.20	292.00
Labor, farm 790 hours at 58¢	458.00
Tractor and truck service 193 hours at 60¢	115.80
Traxcavator service 67 hours, at $5.	335.00
Porch lumber	77.87
Gate lumber and labor	70.80
Gate hardware	72.66
	$4,866.29

The cubic contents of fill in place was 1,822, plus removal of old aboiteau on the outside of the new construction, (500 cu. yds.), a total of 2,422. Cost per cubic yard was $2.06, per cubic yard in place.

Dyke Construction

The dykes protecting the dykelands of the Experimental Farm, Nappan,are subjected to very severe wave and current action from both the Maccan and Nappan rivers. The Body lies at the junction of the Nappan and Maccan rivers. As a consequence it is subjected to two very active currents, as well as heavy waves. There are indications that the undercurrents in these two rivers do considerably more damage to the river banks at two points, than the regular in and out surface current. On the northeast of the "Upland Island" the damage has been more serious on the south side of the Island.

In 1940 two medium size stone breakwaters were constructed at this vulnerable point. These were placed about 500 feet apart at the point where the current was cutting away the bank at low water level. The object was to study control possibilities.

The construction methods were as follows:

No. 1 Breakwater

Cedar posts were driven in a row from the base of the dyke to low water level and three-inch planks were spiked to the posts. Fairly large stones were dumped on either side from base of dyke to low water level. No. 2 had two rows of posts driven V-shape from base of dyke to low water level. The width at dyke was 20 feet and at low water level the planks came to a point. All posts were tied together with heavy wire to keep them from spreading. Between planks was filled with heavy stones.

Fig. 15. Lowering an Armco sluice onto the bed in an aboiteau.

Fig. 16. Finished aboiteau; face showing protecting brush and staked wings.

The average height would run around five feet, the greater height being next to base of dyke.

The following is a statement of the cost of each:

Cost Summary No. 1 Breakwater

Quarrying and hauling stone	$251.82
Material, lumber, spikes, stakes, etc.	148.44
Cutting and hauling stakes	20.84
Cutting and hauling brush	19.44
Construction work	
Manual labor	158.25
Horse labor	2.28
Tractor labor	14.10
Truck Service	75.00
Foreman's time	70.00
	$760.17

Cost Summary No. 2 Breakwater

Quarrying and hauling stone	$181.15
Horse labor	43.76
Trucking	12.00
Material used, lumber, spikes, stakes, nails, pickets, posts	61.48
Cutting and hauling stakes	9.54
Cutting and hauling brush	12.84
Construction work	
Manual labor	224.70
Horse labor	14.08
Tractor labor	8.60
Truck Service	36.75
Foreman's time	70.00
	$674.90

There were from 350 to 400 hundred tons of stone in each breakwater with a slightly greater tonnage in No. 1 than in No. 2.

These breakwaters reduced, to a very marked degree, the wearing away of the banks, but not sufficiently for long-time protection. Consequently, it was decided to make a further test by constructing two cribbed breakwaters with stone. One was constructed north of the "Upland Island" and the other south of the two previous breakwaters. Both were built up to the base of the dyke, then topped with mud. The size of No. 3 north of Island was 15' wide and 100' long, depth at outer end 35 feet. It is ballasted with approximately 400 tons of stone. No. 4, southwest of the stone breakwater, is 15 feet wide and 120 feet in length and the depth at the outer end is 40 feet. The breakwater is ballasted with approximately 700 tons of stone.

Fig. 17. Staking down brush mattress for river bank protection.

Fig. 18. A mattress when about completed.

Fig. 19. Mattress covers river bank north of No. 2 stone breakwater.

The itemized cost of construction for each one respectively is as follows:-

Cost Summary No. 3 Breakwater

Timber for crib work	$ 590.00
Dragline 43 hours at $10.	430.00
Bulldozer 65 1/2 hours at $8.	524.00
Stone - 400 tons at $2.50 delivered	1,000.00
Labor, 46 hours cutting and hauling brush at 60¢	27.60
Labor, 240 hours on construction at 60¢	144.00
Trucking, 13 hours at $2.50	32.50
Tractors, 13 labor hours at $1.00	13.00
	$2,761.10

Cost Summary No. 4 Breakwater

Timber for crib work	$ 660.00
Dragline 63 1/2 hours work at $10.	635.00
Bulldozer 42 hours work at $8.	336.00
Stones, 300 tons at $2.50 delivered	750.00
Labor, 394 hours, quarrying stone at 60¢	236.40
" 52 1/2 hours, truck-hauling stone at $2.00	115.50
" 36 hours, hauling earth at $2.00	72.00
" 76 hours, traxcavator loading stone and earth	236.40
" 315 hours on construction at 60¢	189.00
" 40 hours cutting brush at 60¢	24.00
" 27 hours hauling brush at 60¢	16.20
	$3,270.50

There were approximately 700 tons of stone put into this breakwater. Of the 700 tons, 400 were quarried from the woods of the Experimental Farm.

There are indications that both breakwaters are going to be effective in protecting the river banks.

Tile Draining of Dykelands

In 1949 an area of 2.35 acres dykeland was tile drained. Two types of drainage tiles were used in this test. Section 1 was drained with 4" "No-Corrode" fibre pipe, with holes drilled on two sides. These tiles were 8 feet in length and are joined together by a drive-on coupling or sleeve. Section No. 2 was laid with regular 4" clay tile, with 4" boards under the tile to prevent displacement in the soft soil. One of the difficulties experienced in laying tile on dykeland soil is to obtain a firm, even tile bed. Some spots may be reasonably firm, while others will be very soft. Dykeland soil being so impervious to water, the drains were laid at 20-foot centres. The close drainage adds greatly to the cost. The purpose of this test was to gather data on the efficiency of each of the tile types, as well as the cost per acre.

The following are the data on cost of installing each type of tile:-

No-Corrode "fibre tile 4"

2100 feet of "No-Corrode" tile at 21¢	$440.00
2100 feet of ditch, machine dug, at 4.1¢ per ft.	86.10
2100 feet piping laid and coupled	33.60
2100 feet back filling	18.06
	$577.76

Land tile 4"

2100 feet of ditch, machine dug, at 4.1¢ per ft.	$ 86.10
2100 feet land tile at 3¢	63.00
2100 feet 4" boards at $60. per M.	126.00
2100 feet 4" boards, laid	39.93
2100 feet back filling	18.06
	$333.09

At present-day cost of labor and material, the above figures show that both types of drains are prohibitive for general dykeland purposes.

All dales on this area were brought up to a uniform level to permit water to flow towards drains. All dales were slightly crowned. As the area was fairly rough it required the moving of considerable earth in addition to levelling to cut out water pockets, and allow free flowing of water towards the drains. The average cost per acre for this work was $94.00

The cost of digging the drainage ditches by machine was 4.1 cents per foot as compared with 6.05 cents per foot by hand. The average depth of the drains was 3 1/2 feet.

In 1950 a second area of 2.74 acres south of the Island was tiled. The method followed was entirely different from the first. In this test the old dale ditches were cleaned to a specific grade. Narrow boards were laid under the tile to hold them in line. The average depth of these drains was 2 1/2 feet.

The following are the items of cost for the 2.74 acres:-

Cleaning and laying tiles 150 hours	$102.00
2100 feet of 4" tiles at 3¢	63.00
1600 feet of 4" boards at $60.00	96.00
Backfill by hand 68 hours at 68¢	46.24
Tractor labor, hauling, 33 hours at $1.	33.00
Traxcavator levelling, 11 hours at $5.00	55.00
	$395.24

The average cost per acre in this test was $144.24. Under present-day prices the cost of drainage makes it too expensive for general practice. One would require special cash crops to obtain a return value on investment.

Fig. 20. Stone breakwater built in 1940 to prevent current cutting river bank.

Fig. 21. Putting the heavy stones in the breakwater with tractor and mud sled.

DALE CONSTRUCTION AND DRAINAGE

Nine dales were crowned during 1950 and 1951. The object of these studies is to determine how effective the crowning of dales is on drainage and production.

The first four dales were crowned with a power road grader. The widths of the dales were 61', 60', 61' and 60'. The acreage in each dale was 0.71, 0.78, 0.82 and 0.85 acres respectively. The dales were crowned to an average grade or slope of 11 to 1. Figures 26 and 27 give some indication of the slope of the dale and how machines may operate right down to the centre of the ditch.

In the second series there were five dales. Four were crowned in 1951 with a light horse grader and the first dale was plowed with the Whirlwind terracer, followed by the light grader. The grade or slope was less than in the former series of dales. The range in slope or grade was from 11/1 to 28/1. These two series should, within a few years, supply some very useful data.

The following is a summary of the cost:-

Average cost per acre with Whirlwind terracer	$ 49.00
Average cost per acre with power grader	63.30
Average cost per acre with light horse grader	107.60

The crowning of the dales will effect an annual saving on maintenance work of from $1.00 to $2.00 per acre. That is, in cleaning ditches and cross draining of dales. What the saving in machine operation will be is difficult to state, but the saving in hand raking of ditch banks and the general efficiency of machine work should amount to a creditable figure.

Fig. 22. In 5 or 6 years the silt fills in around breakwater and covers brush mattress.

Fig. 23. Large breakwater of crib and stone built at the Experimental Farm in 1950. Approximately 700 tons of stone were used as ballast.

Fig. 24. Bulldozer building dykes at Experimental Farm, Nappan.

Fig. 25. The finished dykes. Note the excellent sloping sides, both inside and outside of dyke.

Fig. 26. Four 60-foot dales were crowned with a road grader in 1950 to test the efficiency of such a practice. This eliminates cross drainage and facilitates machine operations.

Fig. 27. Shallow dale ditches.

Fig. 28. Draglines starting a new dyke. Draglines are used for the most part on soft ground where bulldozers cannot operate.

Fig. 29. The above picture gives some idea of the tremendous amount of work involved in protecting dykes and aboiteaux from the heavy wash of the sea.

RESUME

1) For the successful cultivation of dykelands it is essential to have:
(a) good dykes, well protected.
(b) good drains, properly maintained.

2) Dykes and aboiteaux can be efficiently constructed with either a bulldozer or a dragline.

3) Soil conditions will govern which of the two machines should be used.

4) On reasonably firm to firm ground dykes can be constructed more cheaply with a bulldozer than any other machine thus far tested.

5) On soft to very soft ground the dragline, worked from mats, is the only machine tested that can do an effective job.

6) There are occasions when it is an advantage to use the two machines in combination.

7) For general construction on soft ground the 3/8 yard dragline has proved most efficient.

8) All badly exposed dykes and aboiteaux banks require proper protection. This will extend their longevity to a marked degree.

9) For dyke protection, planks, stones and brush and stakes have each proved satisfactory.

10) Stone facings are the most durable, but are usually too expensive. Planks have been most commonly used on badly exposed dykes, but planking is becoming increasingly expensive. Brush, when properly placed and properly staked, may frequently be used with a fair degree of success.

11) To prevent soft mud from oozing or spreading during the construction of dykes and aboiteaux, no material, cost considered, has yet been produced to take the place of good brush, properly placed and well staked.

12) Tests have shown most dykeland soil to be fairly acid. Applications of 1 1/2 to 2 1/2 tons of ground limestone have given excellent results at Nappan. Generally speaking, 1 1/2 tons applied every six years is the most economical practice to follow.

13) Limestone applications on dykeland at Nappan have shown returns up to $30 on the average for every ton of lime applied during a 29-year period.

14) Even though dykeland soils have proved to be extremely fertile they have, nevertheless, shown satisfactory response to light applications of nitrogen and superphosphate, basic slag, wood ashes, and barnyard manure.

15) Dykeland soil has given good returns from light applications of barnyard manure, nitrogen and superphosphate when applied in the spring as a top-dressing on permanent sod areas.

16) Tests indicate that it is a good practice to plow dykeland every 3 or 4 years. Yields and quality of hay drop off rapidly after the sixth year.

17) Wider dales are more satisfactory than the narrow types. They increase the productive area and greatly facilitate machine operation. Tests to date indicate that dales from 65 to 75 feet, slightly crowned, are highly satisfactory. The efficiency of wider dales is now under test.

18) Dykeland, when well drained, will grow good crops of most kinds of vegetables. At Nappan beans, beets, swedes, carrots, spinach and celery have been grown. Spinach and celery do exceptionally well.

19) The dykelands of the Maritimes, when well protected by good dykes, limed and cultivated, are extremely productive. They are among the most fertile soils in the world. They hold a much greater potential agricultural value than has heretofore been realized. The time is not too distant when these lands will prove, if they have not already done so, to be the most naturally fertile soils in Canada. Therefore they are a most valuable possession.

Pictorial History of

the Construction

of the

HABITANT ABOITEAU

CANNING, N. S.

THE FOLLOWING TWENTY-TWO PHOTOGRAPHS DEPICT
THE CONSTRUCTION OF THE HABITANT ABOITEAU
CANNING, N. S.
1944-45

October 31, 1944
Driving preliminary piles to carry pile-driver out to site of sluice box. N. end of S. road-dyke seen at left.

November, 1944
South road-dyke seen from south side of marsh. Truck road leads to S. borrow pit to right of picture. Marsh to left of road will be reclaimed.

February, 1945
Downstream end of piling. Wakefield sheet piling may be seen through the round piling.

February 10, 1945
High tide with ice jam. Feb. 12, tide over floor of pile driver. Looking up river; town of Canning in the distance.

April 18, 1945

Floor of sluice box. A workman is caulking the floor. Beside him is a piece of timber fitted with handles for tamping the floor timbers down as the drifts are driven. Floor timbers were set up firmly with jacks; then the holes drilled for drifts.

May 2, 1945

First wall timber laid (left side).

May 25, 1945

Finished roof of sluice box. Wakefield sheet piling may be seen at the upstream end of the sluice. Note the hose from the air compressor to the drill.

June 8, 1945

Sluice covered with layer of clay; clay and brush on the outer side. Trucks dumping rock on downstream end of sluice. A shovel mat is used to form a bridge on to the sluice. Some brush may be seen at the toe of the rock dump. Apron walls in place. Shovel loading rock from stock pile. The plan was to carry the rock dump across the river; then carry a similar dump across the river at the upstream end of the sluice; then fill between with common fill. If possible, it was desired to carry the two rock fills and the earth fill up nearly simultaneously.

June 16, 1945
Looking south across dump. The rock dump had been carried across at low water. The outgoing tide had swept a part of the fill away. Note the rock on the sod on the south side, remaining after opening cut through the dump.

June 16, 1945
Shoving out rock with the bulldozer. Note how the bank has been undercut and fallen in.

August 13, 1945
From north side looking at pole apron below dam.

August 14, 1945
Looking north at high crib from south embankment.

August 18, 1945
Looking south across river. Incoming tide pouring over cribwork. Note ripples from water flowing through the crib in the lower left corner.

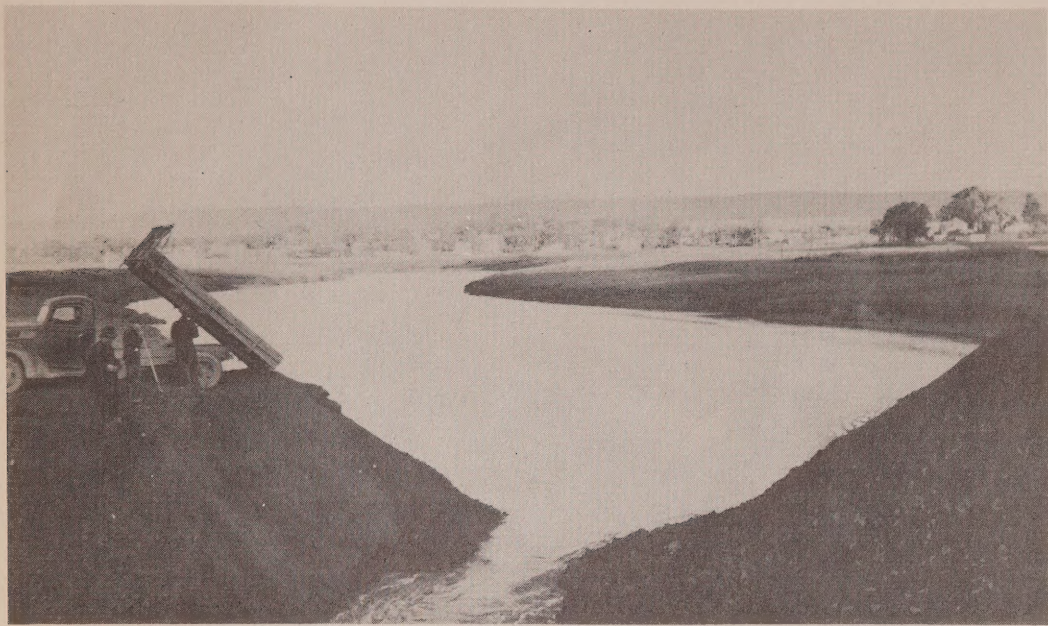
August 23, 1945
Looking north across river; outgoing tide. Note the portion of cribwork on the south bank (lower left corner). The crib was made higher at each side and lower across the middle.

September 8, 1945
Looking upstream from south bank. Crib nearly up to grade; rock being dumped over side, strengthening toe of cribwork.

September 13, 1945
Looking north from south bank. Common fill being placed from north side; trucks hauling and 'dozer compacting and shoving out. Machines approximately over sluice, the headwall of which can be seen to the left.

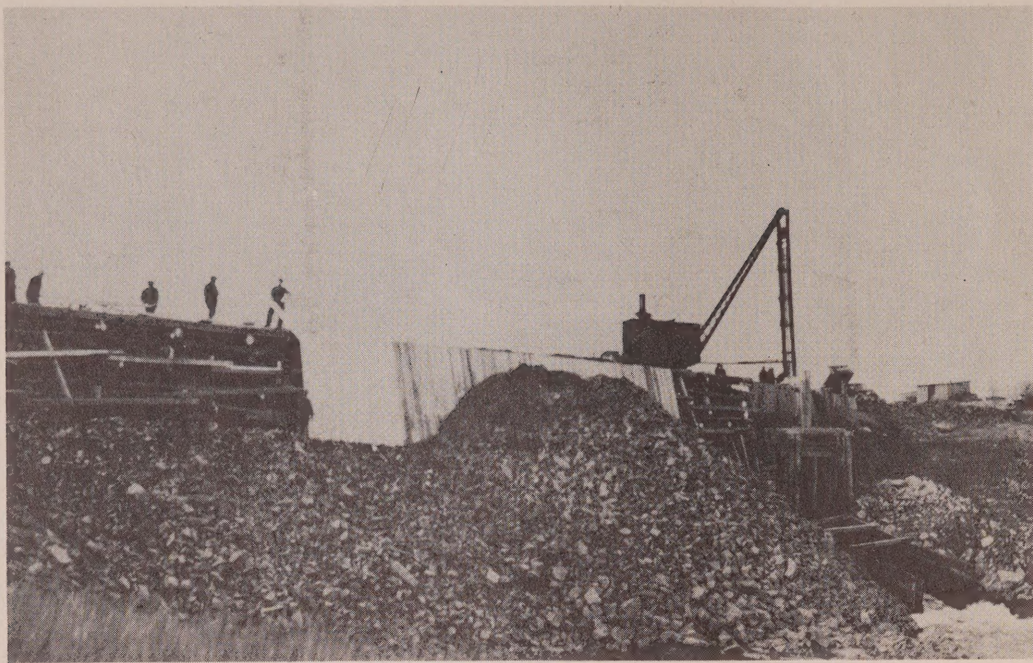
September 27, 1945
Looking downstream from south bank. The two upstream fills nearly closed. Cribwork in background. Rising tide, water flowing upstream through gap between fills.

September 27, 1945
Looking upstream from cribwork. Closing gap between fills.

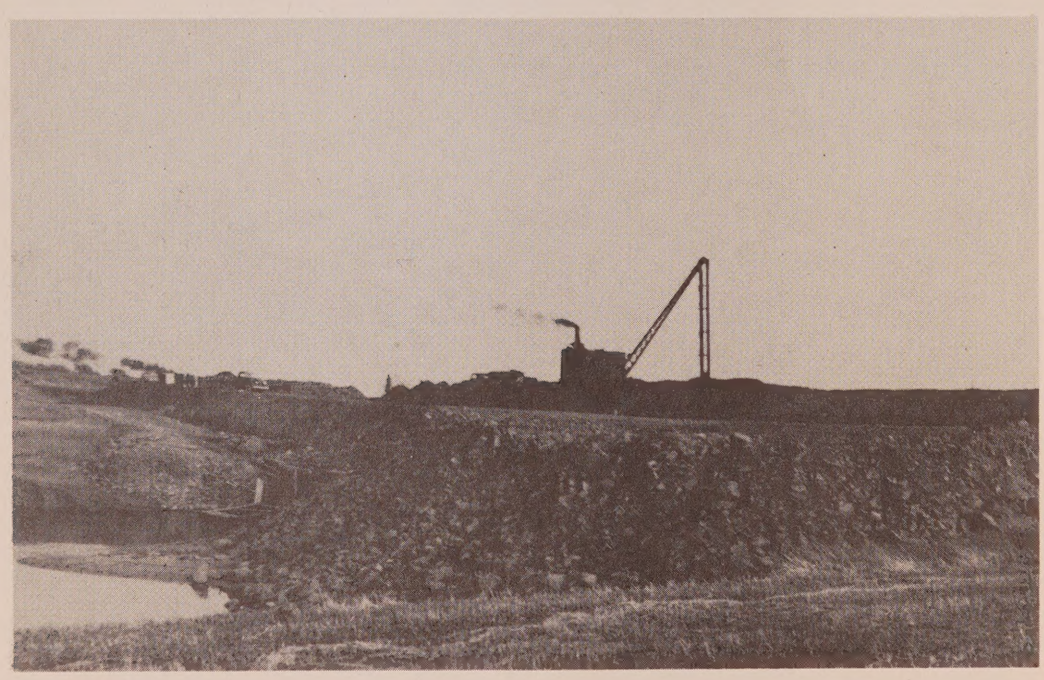


October 12, 1945
From top of crib, looking west at the fills meeting. On September 29 and 30, the fills were brought together and almost up to high-water mark. It was not possible to get the fill above the water level, and the tide broke through with a 20' to 30' gap. This picture shows the second trial of closing.

October 12, 1945. 9:15 A. M.
From top of crib looking west, at small cut and sand bag closing of the river. A wooden box is being pushed out into the gap to check the erosion of the water confined in a narrow channel. Men are passing down sand bags to be placed in the box; then fill will be shoved out over it.



October 31, 1945
From south side looking at face of aboiteau with plank sheathing and rock.



October 31, 1945
From south side looking at riprap on upstream side of aboiteau.

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